The Problem of Induction

Knowledge beyond experience?

What is induction?

- Induction = inductive inference
  - *Inductive* inference is contrasted with *deductive* inference.

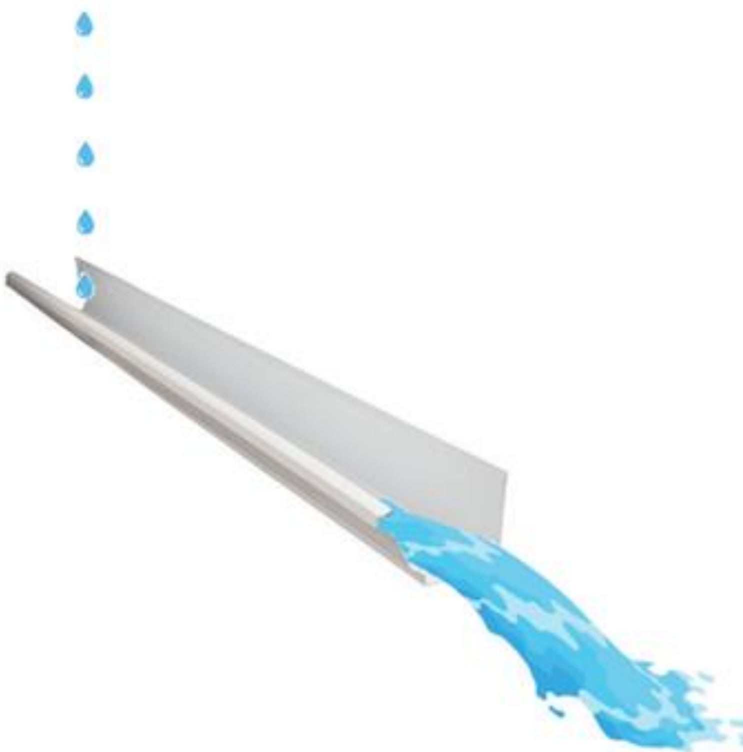
- A deductive conclusion is *100% certain*, given the premises.
- An inductive conclusion is merely *probable* given the premises.

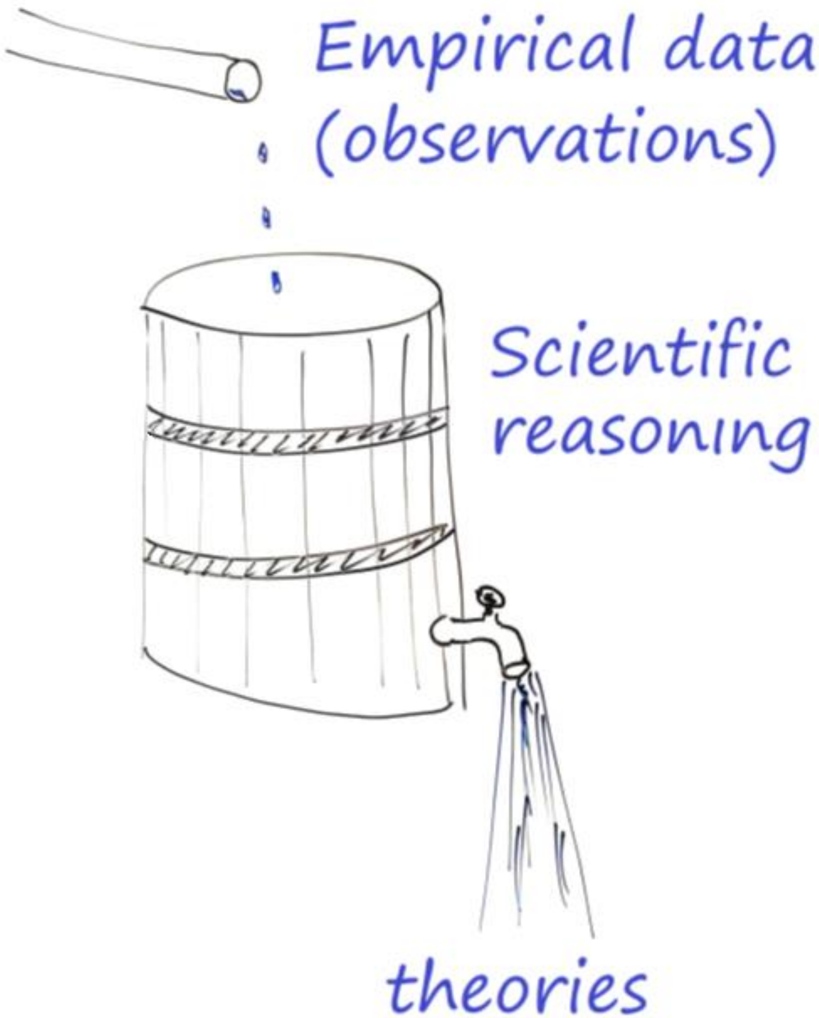
What is “induction”?

- Data (observations) --> Theory / hypothesis

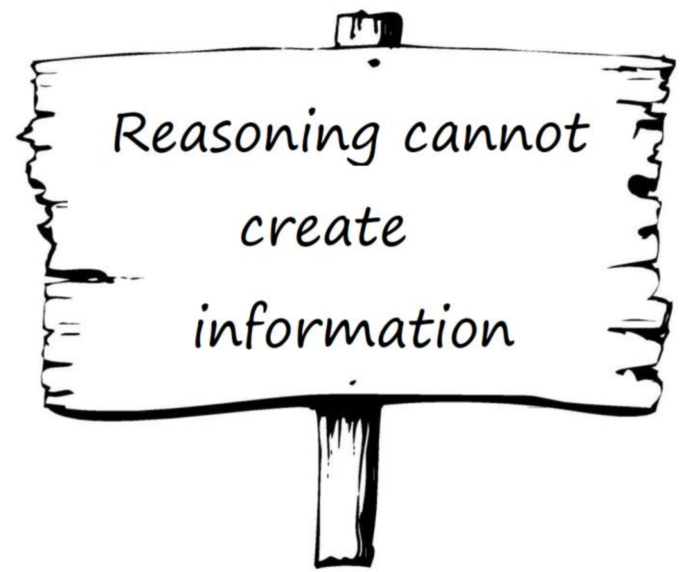
- In general, these inferences use the method of *inference to the best explanation*.

- These inferences are inductive since there is always **more than one possible explanation** of the available data.





N.B. Quine refers to observations as "the meager input", and the theories we infer from them as "the torrential output".



The argument from induction

1. In any scientific inference, the conclusion contains information not provided to us by sense experience.
2. In any rational inference, the information in the conclusion cannot go beyond the premises. (Reasoning cannot create information.)
3. Scientific inferences are rational.

∴ Scientific inferences require *a priori* knowledge.

Huygens' method of induction

Treatise on Light, 1678

- One finds in [Optics] a kind of demonstration which does not carry with it so high a degree of certainty as that employed in geometry; and which differs distinctly from the method employed by geometers in that they prove their propositions by well-established and incontrovertible principles, while here ***principles are tested by the inferences which are derivable from them.***

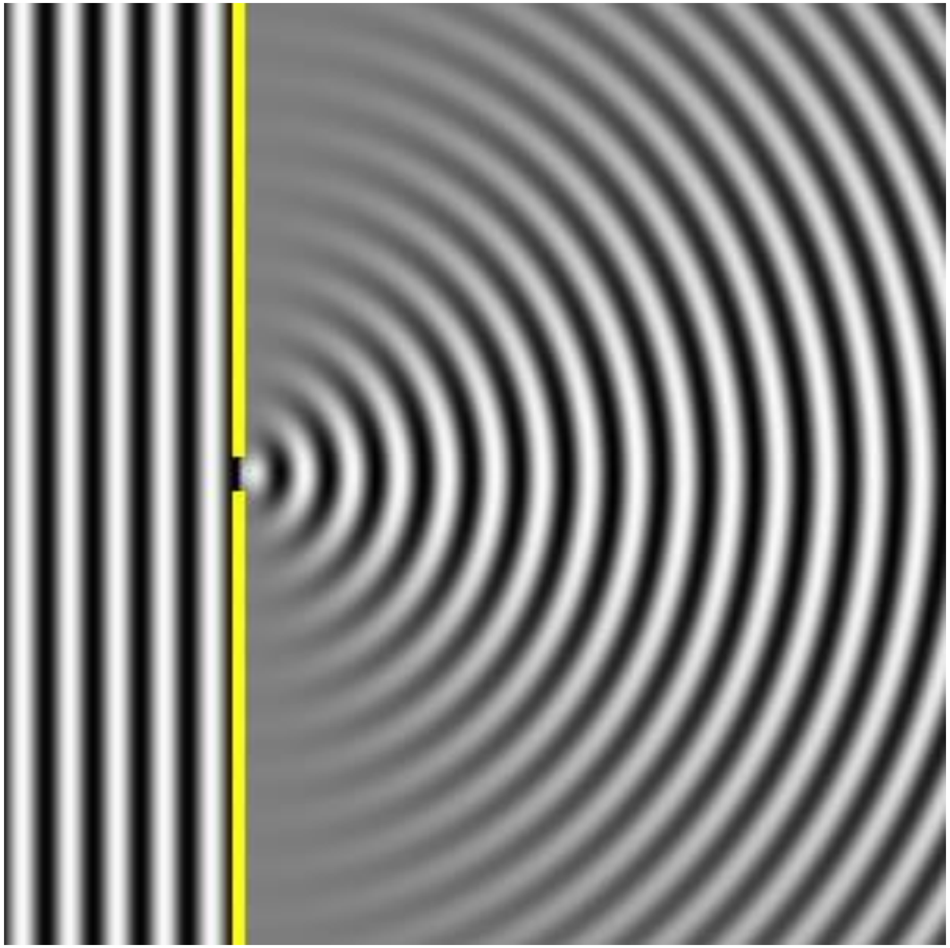
(Theory → Observation statement)

(Backwards reasoning)

Christiaan Huygens, 1629 - 1695

Light waves are invisible …

Slit width = wavelength



Huygens’ new “kind of demonstration” has the following structure:

H predicts phenomena $\mathbf{E}_1$, $\mathbf{E}_2$ and $\mathbf{E}_3$

$\mathbf{E}_1$, $\mathbf{E}_2$ and $\mathbf{E}_3$ are observed to occur

----

$\therefore$ H is probably true

Affirming the consequent!!

Simple test case

Let E_1, E_2 and E_3 specify the outcomes of three tosses of a coin, say *heads* in each case.

H_1 = "this particular coin must *always* land heads"

H_1 predicts phenomena E_1, E_2 and E_3
E_1, E_2 and E_3 are observed to occur

$\therefore H_1$ is probably true

- (Premise 1 is true here. Also premise 2 is true.
- *Is* H_1 probably true?

A priori improbable theory?

- One argument against H_1 being probably true is the fact that it's hard to see how a coin could be made to land heads *every* time.
  - (The coin looks normal, let's suppose, with the Queen's head on one side and "tails" (no head) on the other.)

- *Before* the coin is ever tossed, H_1 might seem "unlikely" or "implausible" in some sense.

Alternative hypotheses?

- Also, there are cases where two or more incompatible hypotheses predict the same data.
- E.g. if a person starts vomiting, then it could be food poisoning. *Food poisoning predicts vomiting*.
  - But stomach flu also predicts vomiting, so it would be hasty to conclude that the person has food poisoning.
- Surely one cannot conclude that H_1 is probably true, without considering the alternatives to H_1 that predict the same data?

In other words, Huygens' method is incomplete in two ways:

1. The scheme takes no account of the *alternatives* to H that might exist, and
2. The hypothesis H in question might have a low *prior* probability
   - i.e. it might seem unlikely given our background information, or general knowledge of the world.

Degrees of prediction

H_1 : The coin *must* land heads. $P(\text{heads} \mid H_1) = 1$

H_2 : The coin is fair. $P(\text{heads} \mid H_2) = ½$

- Does H_2 predict the data E = “all 3 tosses land heads”?
- Sort of. But not with *certainty*. According to H_2, this observed outcome has probability 1/8.
- This probability is expressed as $P(E \mid H_2)$ and is called the *likelihood of the evidence* under H_2.
  - Or just “the likelihood of H_2”, but this is a bit confusing.

- I.e. $P(E \mid H_1) = 1$, but $P(E \mid H_2) = 1/8$.

Three important probabilities

- **Prior** (of the hypothesis)
  - $P_K(H)$ = The probability of H in the epistemic state K, *prior* to learning the evidence E.
- **Likelihood** (of the evidence)
  - $P_K(E \mid H)$ = The degree to which the hypothesis H predicts the evidence E, in K. *Assuming* that H is true, how likely is E to occur?
- **Posterior** (of the hypothesis)
  - $P_K(H \mid E)$ = The new probability of H, in the epistemic state K + E, i.e. *after* learning that E is true.

The “strength” of a hypothesis

- According to Bayes’ theorem (1764), Huygens’ method is basically on the right track, but needs to be supplemented.

- To use Bayes’ theorem, one has gather the new data (call it E) and then enumerate all the possible hypotheses that could possibly explain E. Call the hypotheses H_1, H_2, H_3, … (etc.)

- Then one has to calculate the “strength” of each hypothesis as an explanation of E.
  - *Strength*(H_i) = *prior* × *likelihood* = $P_K(E \mid H_i)P_K(H_i)$

Bayes' thorem

- I.e. a "strong" explanation of E is *both* plausible (prior to the data) *and* predicts the evidence well.

Bayes's theorem then can be expressed as:

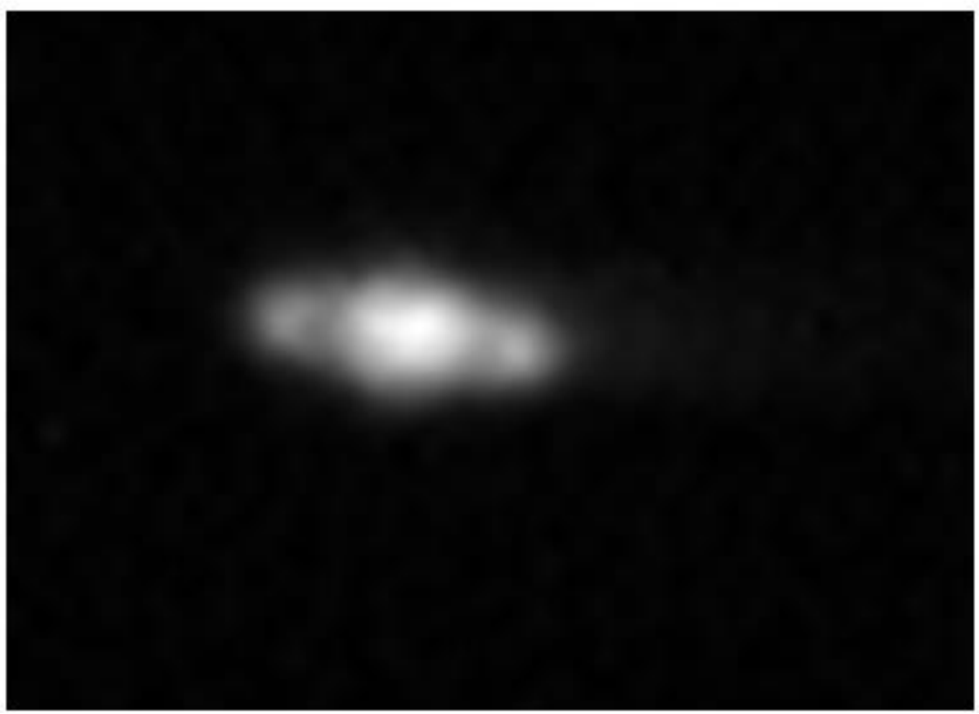
$$P_K(H_1 \mid E) = \frac{Strength(H_1)}{Strength(H_1) + Strength(H_2) + \ldots + Strength(H_n)}.$$

Coin example again

- In the coin example, the “always heads” hypothesis H_1 beats the “fair coin” hypothesis H_2 in predicting the data.
- But perhaps the “fair coin” hypothesis has higher prior probability?
  - For example, if $P(H_1) = 1/100$, but $P(H_2) = 99/100$, then what is the **strength** of each hypothesis as an explanation of the evidence (E = “all 3 tosses land heads”)?
  - If these are the only possible hypotheses, then what is the *posterior* probability of each hypothesis?

E.g. What's up with Saturn?

In 1610 Galileo looked at Saturn through his telescope and saw something like the image below. How do we best explain this data?



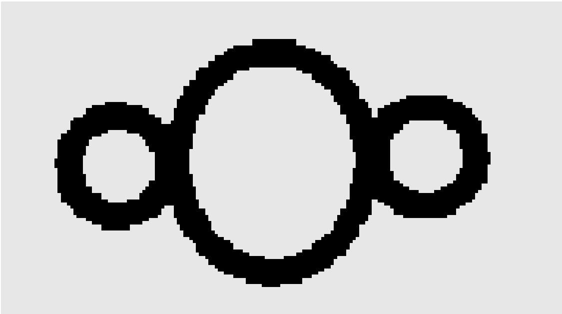
Competing Hypotheses

- H_1: Saturn is a composite of 3 planets, with two equal small planets flanking the main one.
- H_2: Saturn is a giant soup tureen, with handles.
- H_3: Saturn has a flat ring around its equator

1st Hypothesis: a triple planet

On 30 July 1610 Galileo he wrote to his Medici patron:

> "the star of Saturn is not a single star, but is a composite of three, which almost touch each other, never change or move relative to each other, and are arranged in a row along the zodiac, the middle one being three times larger than the lateral ones, and they are situated in this form:

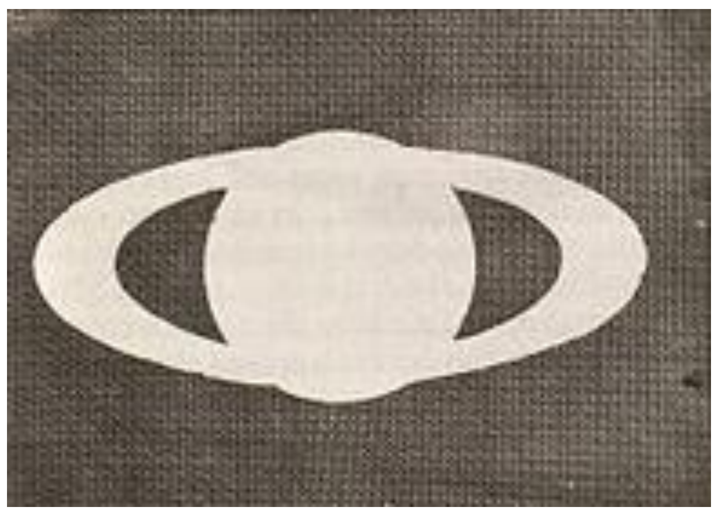


2nd Hypothesis: Giant Soup Tureen

(Galileo never *proposed* this theory. But he did say that Saturn appeared to have ‘handles’, or ‘ears’.)

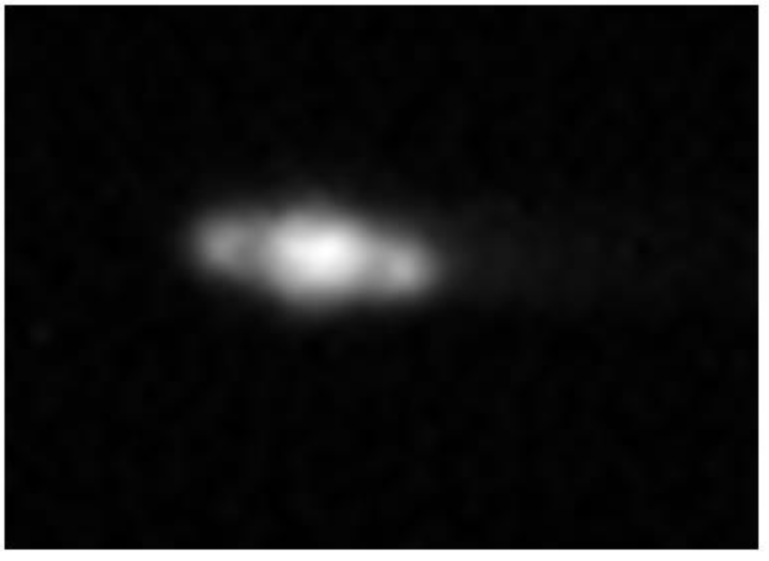
3rd Hypothesis: A Ring

- In 1655, Huygens (again!) proposed that Saturn was surrounded by "a thin, flat ring, nowhere touching, and inclined to the ecliptic."

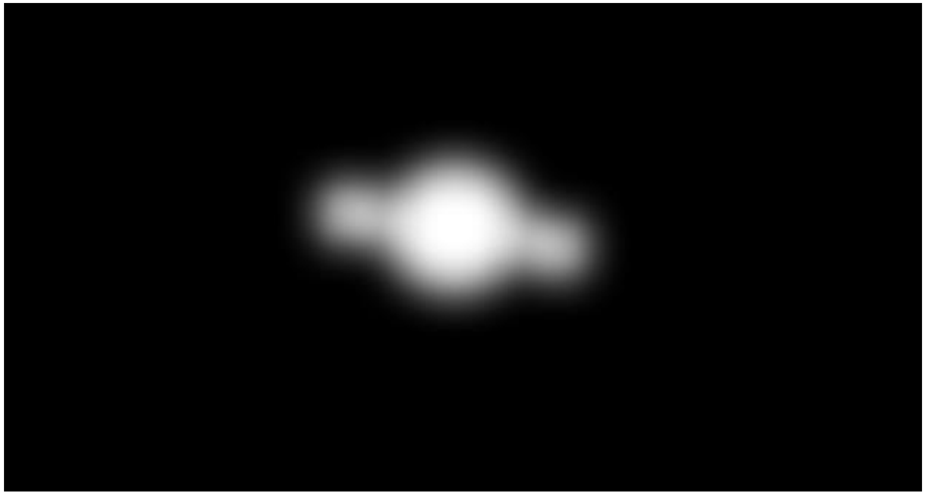


- What is the strength of each hypothesis?

Does H_1 predict the data?



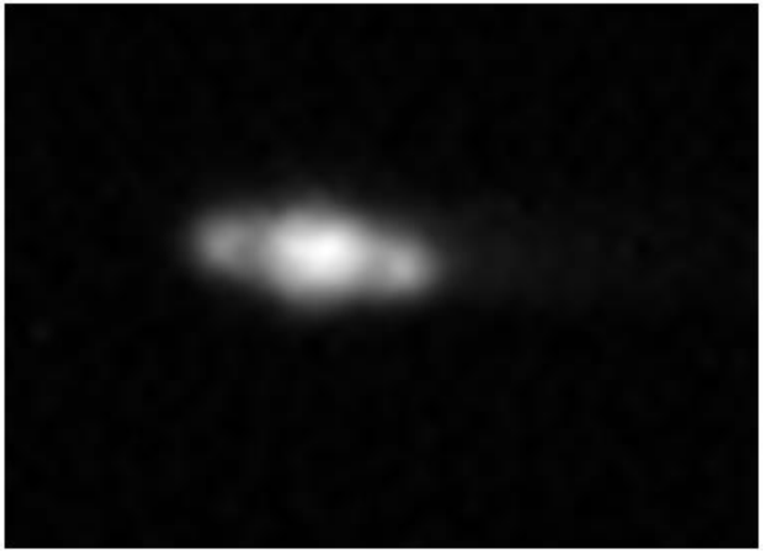
Data



1^{st} theory prediction

Somewhat, but not too great.

Does H_2 predict the data?

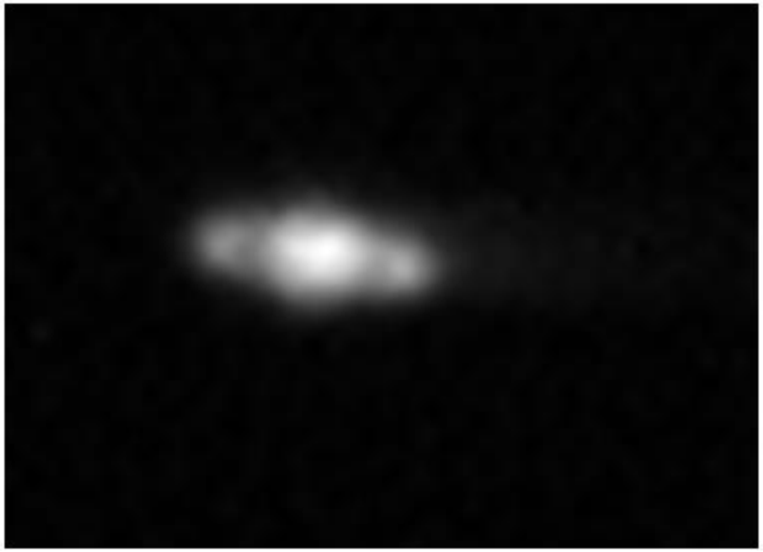


data

2nd theory prediction

A better fit.

Does H_3 predict the data?



data

3^{rd} theory prediction

About as good as H_2.

Overall, which is best?

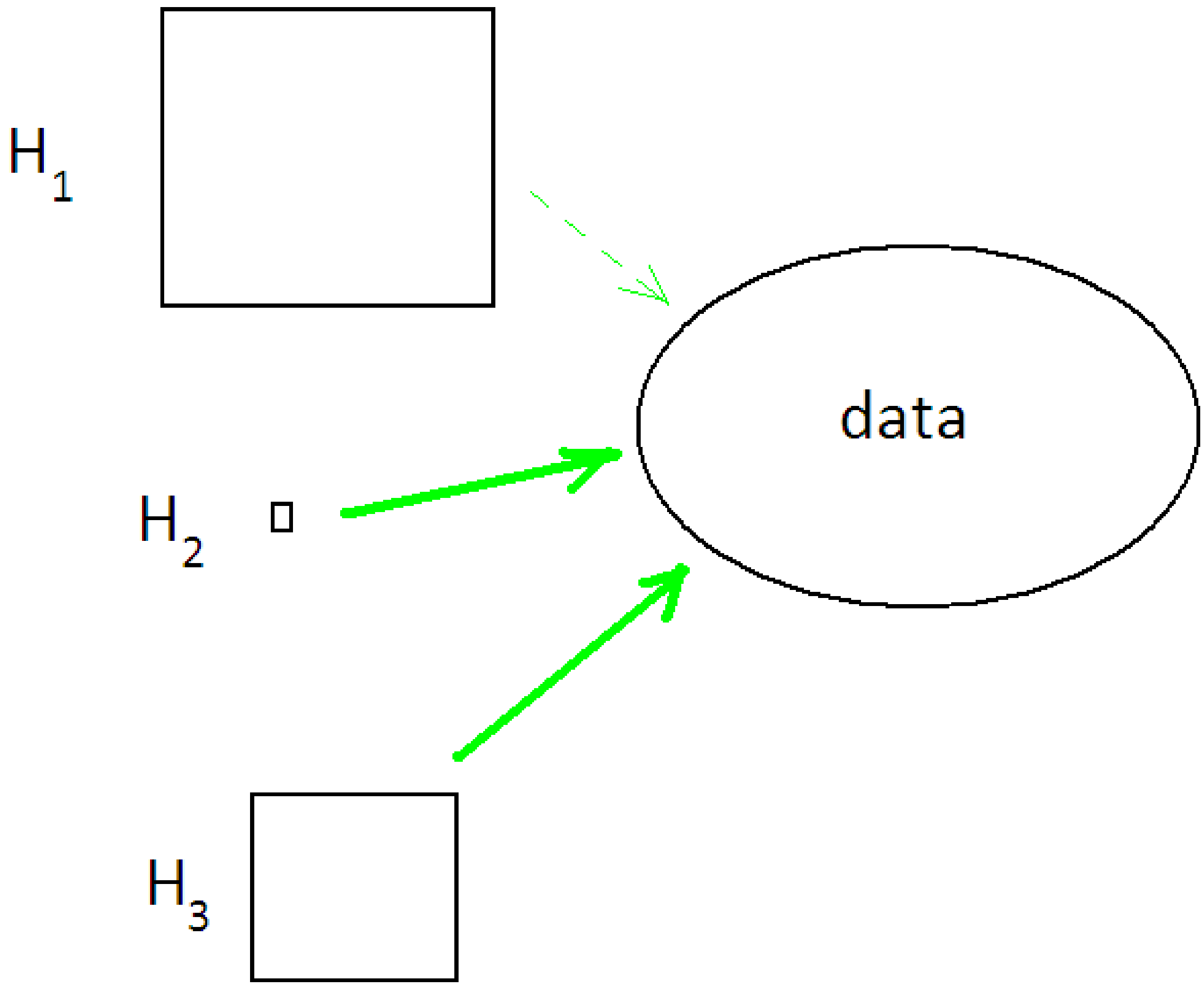
	Cause proposed?	Cause is plausible?	Cause predicts E?
H_1 (triple planet)	Yes	Somewhat	Poorly
H_2 (handles)	Yes	No	Well
H_3 (ring)	Yes	Barely	Well

H_1 is *weak* because it fails to predict the evidence.

H_2 is *weak* because it is implausible.

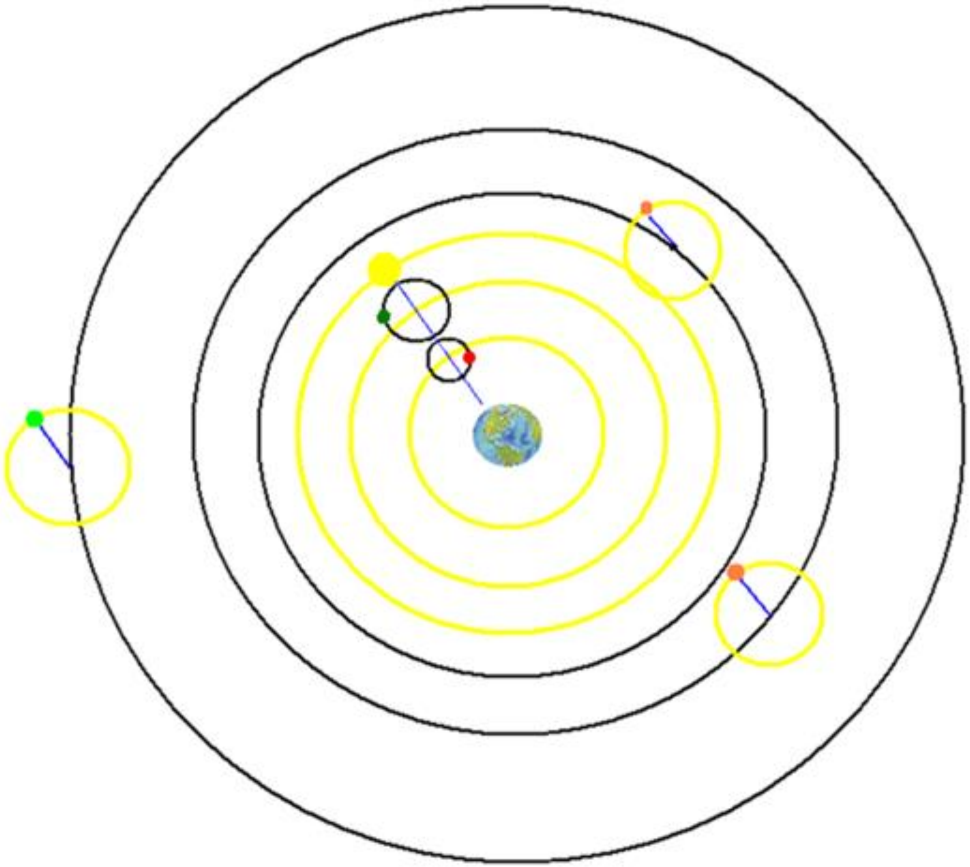
H_3 is *strongest* because it is barely plausible and predicts the evidence.

$\Rightarrow$ H_3 is the best explanation.



(The size of each square represents prior probability, and the green arrows represent logical inference)

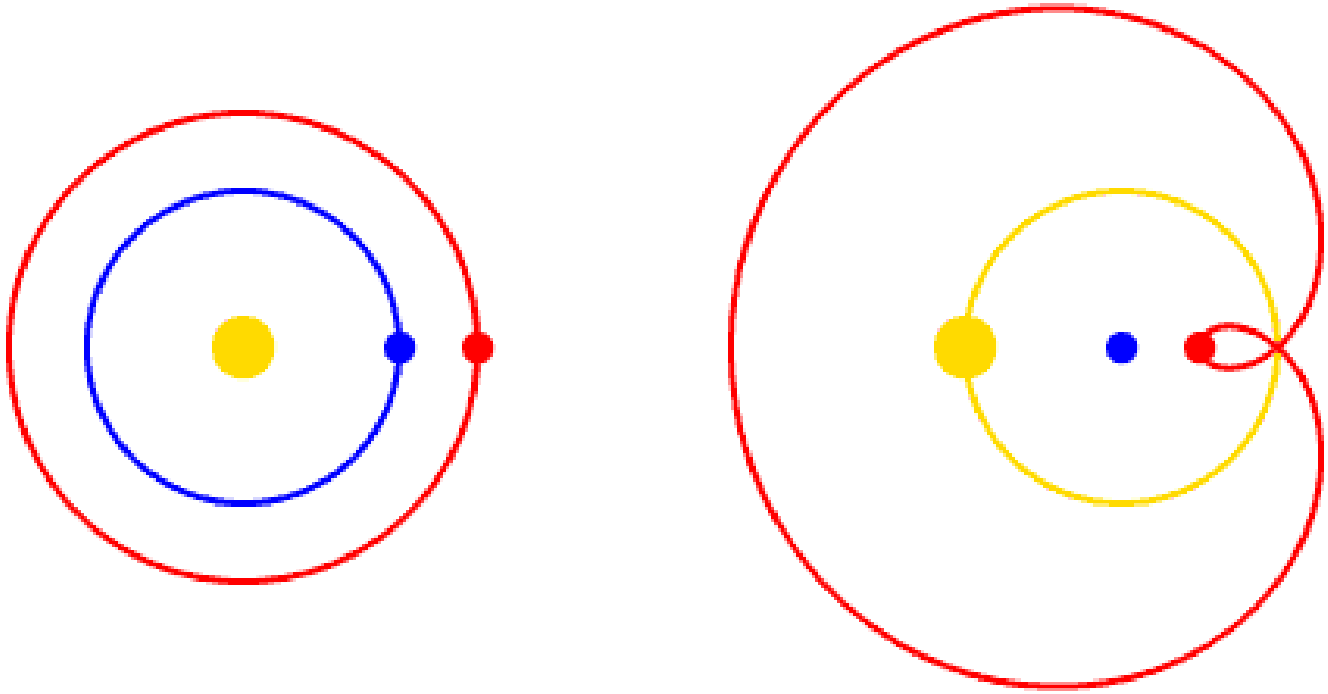
Example: Copernicus's argument



The diagram shows Ptolemy's geocentric model.

The solar orbit, and all its duplicates, are shown in yellow.

Predicting “retrograde” motion



- The orbit of Mars according to Copernicus (left) vs. Ptolemy (right). (Image: Wikipedia)

Less *ad hoc*

- A heliocentric universe, viewed from a central planet, *must* generate these appearances (data):
  - Some (“tethered”) planets always stay close to the sun
  - Other planets can be far from the sun
  - These *untethered* planets all move retrograde when in opposition to the sun

- Copernicus’s theory was much less *ad hoc* than Ptolemy’s.
  - *Ad hoc* = features of a theory driven by empirical data rather than theoretical virtues.

Copernicus's key insight

- "We thus follow Nature, who producing nothing in vain or superfluous often prefers to endow one cause with many effects."

Copernicus, *De Revolutionibus Orbium Coelestium.*

- Thomas Kuhn (Historian and philosopher of science) refers to this as Copernicus's argument from "mathematical harmony".

Criticism of Copernicus' argument

"Harmony" seems a strange basis on which to argue for the earth's motion … **Copernicus' arguments are not pragmatic**. They appeal, if at all, not to the utilitarian sense of the practicing astronomer **but to his aesthetic sense** and to that alone. …

New harmonies did not increase accuracy or simplicity. Therefore they could and did appeal primarily to that limited **and perhaps irrational** subgroup of mathematical astronomers whose Neoplatonic ear for mathematical harmonies could not be obstructed by page after page of complex mathematics leading finally to numerical predictions scarcely better than those they had known before.

- Thomas Kuhn, *The Copernican Revolution*, p. 181.

- What do you think of Copernicus's argument? Did it provide a good reason for accepting his theory?
  - Or was it "sophistry and illusion"?

- "Hume's Fork":

"If we take in our hand any volume; of divinity or school metaphysics, for instance; let us ask, Does it contain any abstract reasoning concerning quantity or number? No. Does it contain any experimental reasoning concerning matter of fact and existence? No. Commit it then to the flames: for it can contain nothing but sophistry and illusion."

(David Hume, *Enquiry* (1748), Section 12 Part 3.)

A priori knowledge?

- It appears that Copernicus's argument against Ptolemy is *a priori*. (Is that true?)

- However, in that case, it seems that *a priori* arguments can establish merely contingent truths.
  – After all, if God wanted to make a Ptolemaic universe, could he do it? Would it be *logically* possible?
  – As with Leibniz, Copernicus could only argue for his universe based on the *wisdom* of God, not logical necessity.

Hume’s argument for induction not being based on reasoning

- An inductive inference has the form:

  Statements about what is directly observed

  ∴ Statements that go way beyond observation

- Hume says you need some sort of “bridge” premise to connect the two subjects. (Like inferences from Belgium to Nepal.)
- “If there were nothing to bind the two facts together, the inference of one from the other would be utterly shaky.”
  - (This seems to be true, just as a matter of logic.)

Cause and effect

- According to Hume, **what connects the two is the relation of cause and effect**. (The cause-effect relation is the ‘bridge’.) Scientific inferences mostly infer causes from effects, but (as Hume points out) there are other patterns. So the inductive argument becomes:

1. Statements about what is directly observed
2. Statements about what causes what

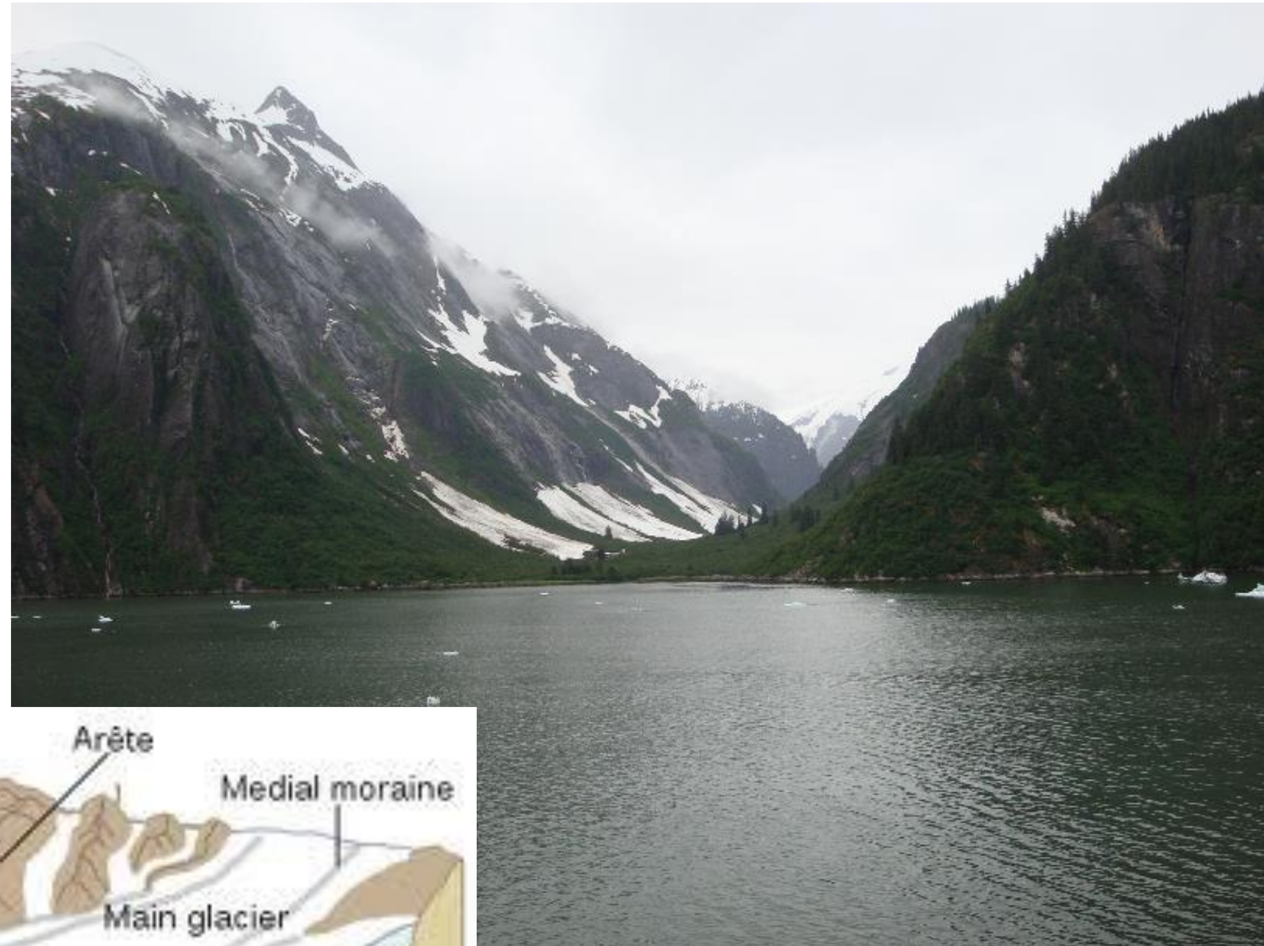
----

3. Statements that go way beyond observation

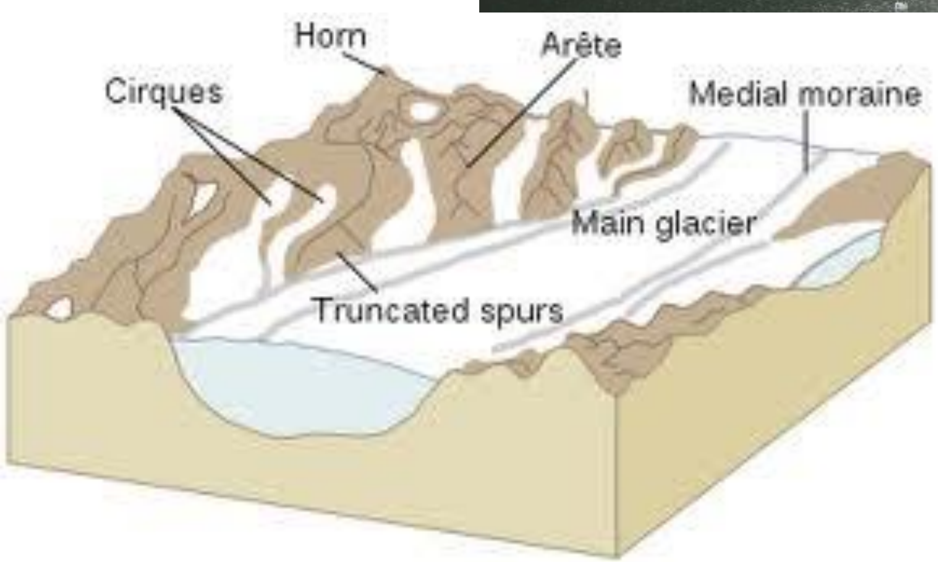
- “All reasonings concerning matters of fact seem to be founded on the relation of C*ause* and *Effect*, which is the only relation that can take us beyond the evidence of our memory and senses.”

- Hume, *Enquiry*, Section 4 Part 1.

E.g.



hypothesis



evidence

- E.g.

1. This valley is observed to be U-shaped
2. Glaciers cause U-shaped valleys

∴ This valley was formed by a glacier

Now add *empiricism*

- “knowledge about causes is **never acquired through a priori reasoning**, and always comes from our experience of finding that particular objects are constantly associated with one other.”

- But now, if premise 2 is entirely derived from experience, *then it adds no information at all to observation statements like premise 1*, and so cannot act as an inferential “bridge”.

- This is (I think) Hume’s central argument against inductive reasoning, in pp. 15-16 of the *Enquiry* (Bennett edition).

- (Hume doesn't *explicitly* make this argument, at least in the *Enquiry*. But the main idea of his argument, I believe, is the logical insufficiency of purely empirical knowledge to take us beyond experience.)

- "All that past experience can tell us, directly and for sure, concerns the behaviour of the particular objects we observed, at the particular time when we observed them."

- "But if you insist that the inference is made by a chain of reasoning, I challenge you to produce the reasoning."

- Where is the intermediate step, the interposing ideas, which join propositions that are so different from one another?

Hume's second argument

- Later, starting on the right-hand column of page 16 in the Bennett edition, Hume considers how we **actually** make these arguments, "in reality". How do we make these inferences?
- "From causes that appear similar we expect similar effects."
- "… all inferences from experience are based on **the assumption that the future will resemble the past**, and that similar powers will be combined with similar sensible qualities."

- But, once again, Hume says, it's quite obvious that we can't learn this from *experience*.
- For example, to use induction: "since induction worked in the past, it will work again" would be *circular*.

Rationalist Response to Hume

- Rationalism (even of a modest sort) would cut Hume's argument off at the roots.
- Hume: It would take a very clever person to discover by reasoning that heat makes crystals and cold makes ice without having had experience of the effects of heat and cold!
- E.g. Maxwell discovered electromagnetic waves (e.g. radio waves) by reasoning, as well as prior data. (This is but one of many examples of this kind.)

- "… it is obvious that if some events can be foreseen before any test has been made of them, we must be contributing something from our side."

G. W. Leibniz, *New Essays on Human Understanding*, 1637, Preface.
(Translation Jonathan Bennett 2017, at earlymoderntexts.com)

"This human subject [infers a 3D coloured model of the world from light rays entering the eye.] The relation between the **meager input and the torrential output** is a relation that we are prompted to study for somewhat the same reasons that always prompted epistemology; namely, in order to see how evidence relates to theory, and in what ways **one's theory of nature transcends any available evidence**."
(Quine, "Epistemology Naturalized", p. 8)

Not much *a priori* knowledge is needed

- A Bayesian rationalist (= objective Bayesian) has, I would say, a very strong response to Hume's argument.
- Bayes' theorem shows how even a *small amount* of *a priori* knowledge can combine with empirical data to give pretty strong (though fallible) theoretical knowledge.
- When Hume says, "I challenge you to produce the reasoning." the objective Bayesian replies, "Here you are."

Bayes supports Hume (up to a point)

- **Bayesian reasoning fully supports Hume's claim that, *in the absence of a priori knowledge, statements about experience cannot tell us about anything else*.**
- E.g. suppose an urn is known to contain a large number of balls, each either black or white.
  - (But we know nothing else.)
- Then we draw (say) 100 balls at random, and see that they are all black.
- According to Bayes' theorem, what is the probability that the next ball selected will be black?
  - Bayes' theorem says: "No idea."
  - (The probability is *undefined*)

Mork, Mindy and Laplace

- In the absence of *any* prior probability distribution over the possible colourings of the balls, Bayes' theorem is helpless.
  - If we assign equal prior probability to every possible colouring, then P(next ball black) = ½, regardless of previous experience, according to Bayes' theorem. (Mindy's rule)
  - If we assign equal prior probability to every possible *proportion* of black balls, then P(next ball black) = 101/102 (Laplace's rule of succession)
  - With the prior assumption that there are initially 100 balls of each colour, P(next ball black) = 0. (Mork's rule)

Alvin Plantinga on induction

“God has created us in his image; this involves our being able to have significant knowledge about our world. That requires the *adequatio intellectus ad rem* (the fit of intellect with reality) of which the medievals spoke, and the success of inductive reasoning is one more example of this adequatio. According to theism, God has created us in such a way that we reason in inductive fashion; he has created our world in such a way that inductive reasoning is successful.

Where the conflict really lies, Ch. 9, Part V.

E.g. Common Rationalist Principles

Objective reality has a rational structure, so that reality is comprehensible.

1. **The relation of cause and effect mirrors the relation of logical consequence.**
   - Effects can be logically inferred from their causes, i.e. from suitably complete descriptions of the total cause. (Or, at least, the *probability* of an effect is logically determined by the causes.)
   - Every event has a cause. (Objects and events don't appear "from nowhere", spontaneously, all by themselves.)
   - If a cause is symmetric, in a certain respect, then its effects (or the probabilities of effects) must also be symmetric, in the same respect.
2. **The Separability Principle**. The spatial and temporal parts of a system can be considered as separate entities, and will behave independently of each other, unless they exert forces upon each other.
3. **The Locality Principle**. Forces on a system can only be exerted by the immediate environment, not by distant objects, except indirectly via a chain of intermediaries.
4. **The Markov principle**. The past states of a system cannot act directly on future states, but only indirectly via the states at intermediate times.

Alvin Plantinga on induction

"… insofar as we have been created in God's image, it is reasonable to think our intellectual preferences resemble his. We value simplicity, elegance, beauty; it is therefore reasonable to think that the same goes for God. But if he too values these qualities, it is reasonable to think this divine preference will be reflected in the world he has created."

Where the conflict really lies, Ch. 9, Part VI.

Rationalist objections to Hume

1. Hume assumes that *a priori* knowledge would be certain. "If this were based on reason, we could draw the conclusion as well after a single instance as after a long course of experience." Rationalist Bayesians reply that *a priori* knowledge comes to us in the form of prior probabilities, so that experience is also needed in most cases.
2. Based on #1, Hume reasons that since experience is *necessary* for a particular kind of knowledge, it follows that that kind of knowledge comes *purely* from experience. (But necessary ≠ sufficient.)
3. Hume claims that *a priori* reasoning about causes would be arbitrary, idle imagining, but the track record of physics (anticipating phenomena) proves otherwise.

An empirical argument for the *a priori*?

1. *A priori* arguments have often anticipated new data.
2. If rationalistic arguments were mere sophistry and illusion then this empirical success would amount to a miracle.

∴ Rationalistic arguments are not illusions

Is this argument self-defeating?

(N.B. Empirical arguments need not be *purely* empirical. The rationalist isn't betraying her position by making empirical arguments!)

Email with Paul Russell (Hume expert)

RJ … this "collision problem" was important in physics since Descartes proposed a solution to it. … Huygens later solved the problem in the 1650s using *a priori* principles like symmetry conservation. On the face of it then, Hume is just wrong to say that reason has nothing to say about cause and effect, and that it must arbitrarily invent or imagine the effect. Does Hume respond to this objection?

PR: These billiard ball example features prominently in Locke's *Essay*, which is, I think, an important source for Hume (and his contemporaries). … I am not aware of Hume having knowledge or interest in Huygens. … I think that Hume's primary sources relating to induction and inference were Hobbes, Locke and Butler. … Again, I am not aware of Hume directly responding to Leibniz in relation to this matter …

Feldman on induction

- “Very roughly, inductive reasoning is reasoning that relies on observed patterns to draw conclusions about what occurs in other cases” (p. 130)
- E.g. the Sun Rise Argument.
  - (The sun has risen every morning we’ve observed so far, so it will rise tomorrow.)
- **Is this how scientific reasoning works?**

Leibniz on induction by instinct

"The ·thought-to-thought· sequences of beasts are just like those of simple empirics who maintain that what has happened once will happen again in a case that is similar in the respects that they have noticed, though that doesn't let them know whether the same reasons are at work. That is what makes it so easy for men to ensnare beasts, and so easy for simple empirics to make mistakes…

… The sequences of beasts are only a **shadow of reasoning**, i.e. a mere connection in the imagination—going from one image to another. When a new situation appears to be similar to earlier ones, the beast expects it to resemble the earlier ones in other respects too, as though things were linked in reality just because their images are linked in the memory."

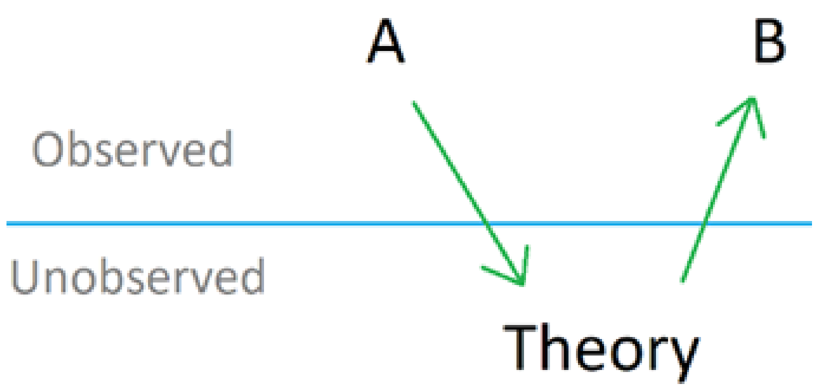
Leibniz, Preface to the *New Essays on Human Understanding*.

“Admittedly reason does advise us to expect that what we find in the future will usually fit with our experience of the past; but this isn’t a necessary and infallible truth, and it can let us down when we least expect it to, if there is a change in the ·underlying· factors that have produced the past regularity. That’s why the wisest men don’t put total trust in it: **when they can, they probe a little into the underlying reason for the regularity** they are interested in, so as to know when they will have to allow for exceptions.”

- Leibniz, Preface to the *New Essays*.

Induction according to Leibniz

- Induction is an inference from observed patterns to their underlying (and often unobserved) causes.
  - Those causes often involve *deep structural facts* about the universe, such as laws, fundamental constants, evolutionary relationships, etc.



Even an inference from one observation statement (A) to another (B) **proceeds via theory**.

IBE and *a priori* arguments

- IBE = Inference to the Best Explanation
- Many, perhaps most, philosophers of science now think that scientific reasoning is generally IBE.
  - IBE involves formulating all the possible explanations of the existing total data, and assigning most of the probability to the “best” explanation.

What makes an explanation “good”?

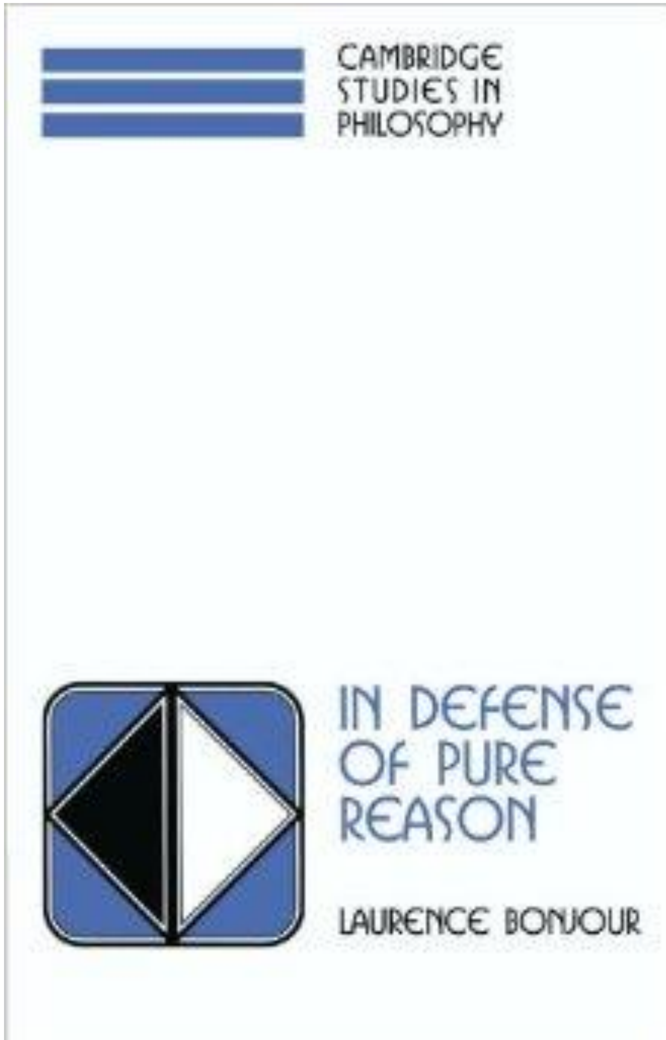
- There’s no exact, universally accepted measure of how “good” a particular explanation H is.
- In my view, the correct measure is the Bayesian one:
  - $\textit{Strength}(\mathrm{H}) = P_K(\mathrm{E} \mid \mathrm{H}) \times P_K(\mathrm{H}) = \textit{likelihood} \times \textit{prior}$

- If you look in a critical thinking textbook, you’ll see a list like:
  - Empirical adequacy
  - Fruitfulness
  - Simplicity
  - Scope
  - Conservatism

- Note that such lists always go beyond mere empirical adequacy, to include things like:
  - The theory fits with existing beliefs
  - The theory is simple, economical, etc.
  - The theory is ‘lovely’, beautiful, etc.

- In other words, IBE is a form of reasoning that **takes non-empirical factors into account**.

Laurence BonJour



Blurb:

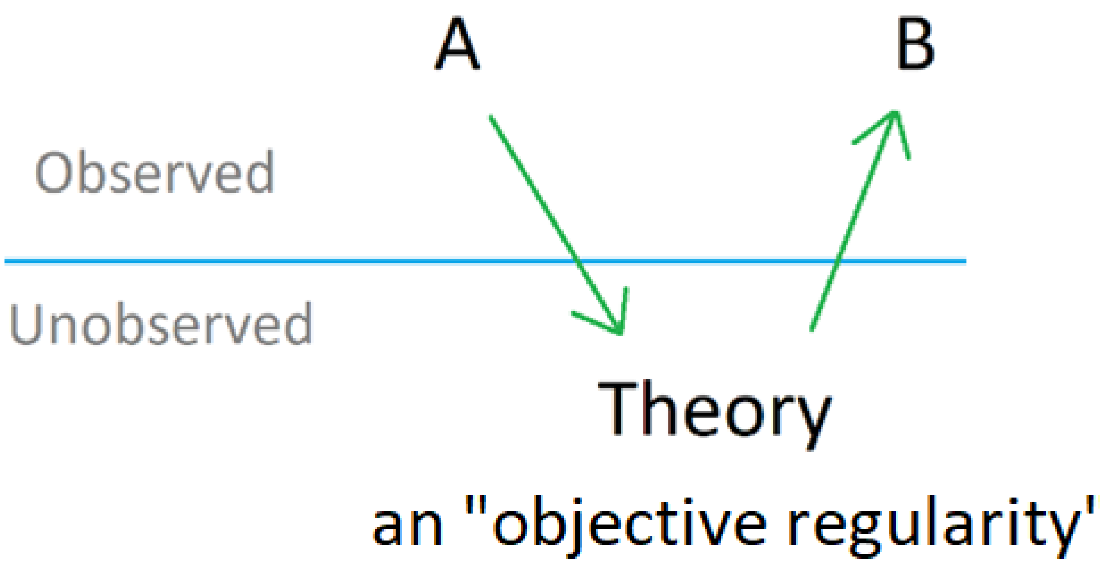
"… Most recent philosophers reject [rationalism] and argue that all substantive knowledge must be sensory in origin. Laurence BonJour provocatively reopens the debate by presenting the most comprehensive exposition and defense of the rationalist view that *a priori* insight is a genuine basis for knowledge."

Laurence BonJour

Belief in laws of nature is supported by IBE:

"What sort of an *a priori* reason might be offered, then, for thinking that a standard inductive conclusion is likely to be true when such a standard inductive premise is true? The intuitive idea behind the reason to be suggested here is that **an objective regularity** of a sort that would make the conclusion of a standard inductive argument true **provides the best *explanation*** for the truth of the premise of such an argument"

(p. 207)



- The postulated "objective regularity" is supposed to *cause* both A and B. It then *explains* A, the observed pattern, and *predicts/explains* B.
  - "… it seems evident, and, as far as I can see, evident **on a purely a priori basis**, that it is highly unlikely that only coincidence is at work"

Similar to the Monty Hall problem

- Why does Monty Hall opening door 2 give you evidence that the prize is behind door 3?

You picked Door 1

MH opened 2 $\Rightarrow$ MH *couldn't* open 3 $\Rightarrow$ MH knows the Prize is behind 3

- In a similar vein, Bigelow, Ellis and Lierse argue that observed stable patterns are best explained by the existence of *essential* properties of matter.
  - "Laws of nature, we claim, derive from the attribution of essential properties to things."
  - "The World as One of a Kind: Natural Necessity and Laws of Nature" by John Bigelow, Brian Ellis and Caroline Lierse, *BJPS*, 1992.

- These fixed essences give rise to the stable patterns we observe in nature.
  - E.g. the charge and mass of the electron, the speed of light, etc. are logical consequences of (necessitated by) the essential properties of matter.

What is an "objective regularity"?

"… the objective regularity that is invoked by the straight inductive explanation must be conceived as **something significantly stronger than a mere Humean constant conjunction**, and in particular as involving by its very nature a substantial propensity to persist into the future. … anything less than this will not really explain why the inductive evidence occurred in the first place: **the assertion of a Humean constant conjunction amounts to just a restatement and generalization of the standard inductive evidence, but has no real capacity to explain the occurrence of that evidence**." BonJour, p. 214.

Humean Laws and IBE

- N.B. On a Humean view, **laws are no more than regularities**. The "mosaic" of actual events in the world is the ultimate reality, with nothing deeper causing it.
  - "If one is a Humean, then the Humean Mosaic itself appears to admit of no further explanation. Since it is the ontological bedrock in terms of which all other existent things are to be explicated, none of these further things can really account for the structure of the Mosaic itself." Tim Maudlin, *The Metaphysics Within Physics, 2007*
- Thus, according to the regularity theory of natural laws, **there is no common cause** of the observable events A and B.
  - So IBE cannot be used to justify induction.

Where is *a priori* knowledge involved?

- If we take a Bayesian perspective, the *likelihoods* are straightforward, being grounded in the postulated "objective regularity", or natural laws, essences, etc.
  - E.g. under the assumption that a coin is biased towards heads, with Chance(heads) = 0.75, then we can assign a probability to every possible data set.

- But what *priors* do we need for induction?
- Can we rationally *justify* such priors?

How do we dismiss Goodman laws?

- An Goodman law is something like:

  “Newton’s laws are followed up to March 8, 2024, but after that <some other law> holds”

- What does *today’s* total empirical evidence have to say about this law?
- Are such laws *logically* impossible?
- Do any purely logical principles (e.g. the probability axioms) render them improbable?
- (Are they *a priori* improbable?)

What if the essential properties *change*?

- Suppose Ellis *et al* are right in saying that laws derive from the essential properties of matter.
- In that case, *if* the essential properties are fixed, stable, etc. then the fundamental laws cannot change.
  - But do we *know* that these properties are stable?
  - What if God decides to increase the charge of (all or some of) the electrons, for reasons that we cannot fathom?
  - What if the world arose from a Primordial Chaos that is inherently unpredictable?
- Inductive beliefs are justified only to the extent that we can rule out such possibilities (it seems to me).
  - Can we rule them out *by experience*? *A priori*?

Alternative responses to Hume

1. Pragmatic justifications of induction
   – E.g. Popper, Reichenbach
2. Ordinary language justifications
   – Strawson, Ayer, Edwards
3. Inductive justifications of induction
   – Bayesian empiricism?

1. Popper’s falsificationism

“I hold with Hume that there simply is no such logical entity as an inductive inference …

[However] I disagree with Hume’s opinion (the opinion incidentally of almost all philosophers) that induction is a fact and in any case needed. I hold that neither animals nor men use any procedure like induction …

The answer to this problem is … we are justified in reasoning **from a counterinstance to the falsity** of the corresponding universal law.”

Popper, “The Problem of Induction”, 1953

Induction/Confirmation argument form:

H predicts E
E is observed
(H is plausible, etc.)

So H is (probably) true

Formally invalid

Falsification/Refutation argument form:

H predicts E
$\neg$ E is observed

So H is (surely) *false*

Formally valid

Popper’s falsificationism

- I.e. Popper says that inductive inferences are **impossible**, and **not needed in science**.

- In other words, Popper is prepared to give up the idea that we can ever rationally *believe* our theories, even to a limited degree.

- Instead, the best theories are merely ones that are falsifiable in principle, but not actually falsified (yet).

Don’t we believe our best theories?

- The main problem with Popper’s view is that scientists *do* seem to believe theories, at least with some degree of probability (that is often fairly close to 1). (“It turns out …”, “We now know …”)
  - And this often seems *justified*.

- Also, if scientific theories are to be applied to real-world problems, then we *need* to believe them.

BonJour on Popper

"Though Popper describes his view as a solution to the problem, it seems to amount mainly to the insistence that the problem as posed here cannot be solved, i.e., that inductive evidence provides no reason at all to think that the corresponding inductive conclusions are true, thus endorsing inductive skepticism rather than even attempting to answer it.

More generally, Popper's overall epistemological view is devastatingly skeptical in its implications, implications that are only lightly disguised by his use of the term 'corroboration' in a highly misleading way that departs strongly from its ordinary meaning."

Ordinary language justifications

- "… the question of whether induction is justified cannot be meaningfully raised and is thus a "pseudo-problem."

- E.g. Strawson (1952):
  - … it is an analytic proposition . . . that, other things being equal, the evidence for a generalization is strong in proportion as the number of favorable instances, and the variety of circumstances in which they have been found, is great. So to ask whether it is reasonable to place reliance on inductive procedures is like asking whether it is reasonable to proportion the degree of one's belief to the strength of the evidence. Doing this is what 'being reasonable' *means* in such a context.

BonJour’s analogy

- Imagine a religious community which accepts some “scripture” as authoritative. What if a sceptic questions whether it’s rational to do this?

- “Of course believing in accordance with scripture results in justified beliefs! Beliefs arrived at in this way are what we mean by “justified beliefs” in this community. It is an analytic truth that beliefs supported by strong evidence are justified; and it is also an analytic truth that being highly in accord with scripture constitutes strong evidence.”

How about Bayesian *empiricism*?

- How does one assign values to the priors?
  - by *experience*.
  - E.g. belief in uniform laws would *initially* be unjustified, but in the 21st century those priors are justified by the past successes of science.

- To some extent that's fair enough, as the "priors" at any given time are based on previous observations, at least in part.
  - But is there a kind of regress problem here?
  - Does Bayes' theorem allow probabilities to be determined by experience "all the way down"?
  - Does Bayes's theorem require **absolute priors**?

Collect together *all* our evidence?

- Put *all* our observations, that the whole human race has collected since the beginning of history, into one *massive* proposition E.
- Then, according to Bayesian methods, we should believe a hypothesis H_1 if $P(H_1 \mid E)$ is high.
  - Note that there is no '*K*' here, as we now have no background knowledge (since there is no experience prior to E).
- *But*, calculating $P(H_1 \mid E)$ requires values for $P(H_1)$, $P(H_2)$, $P(H_3)$, etc., which are absolute priors.

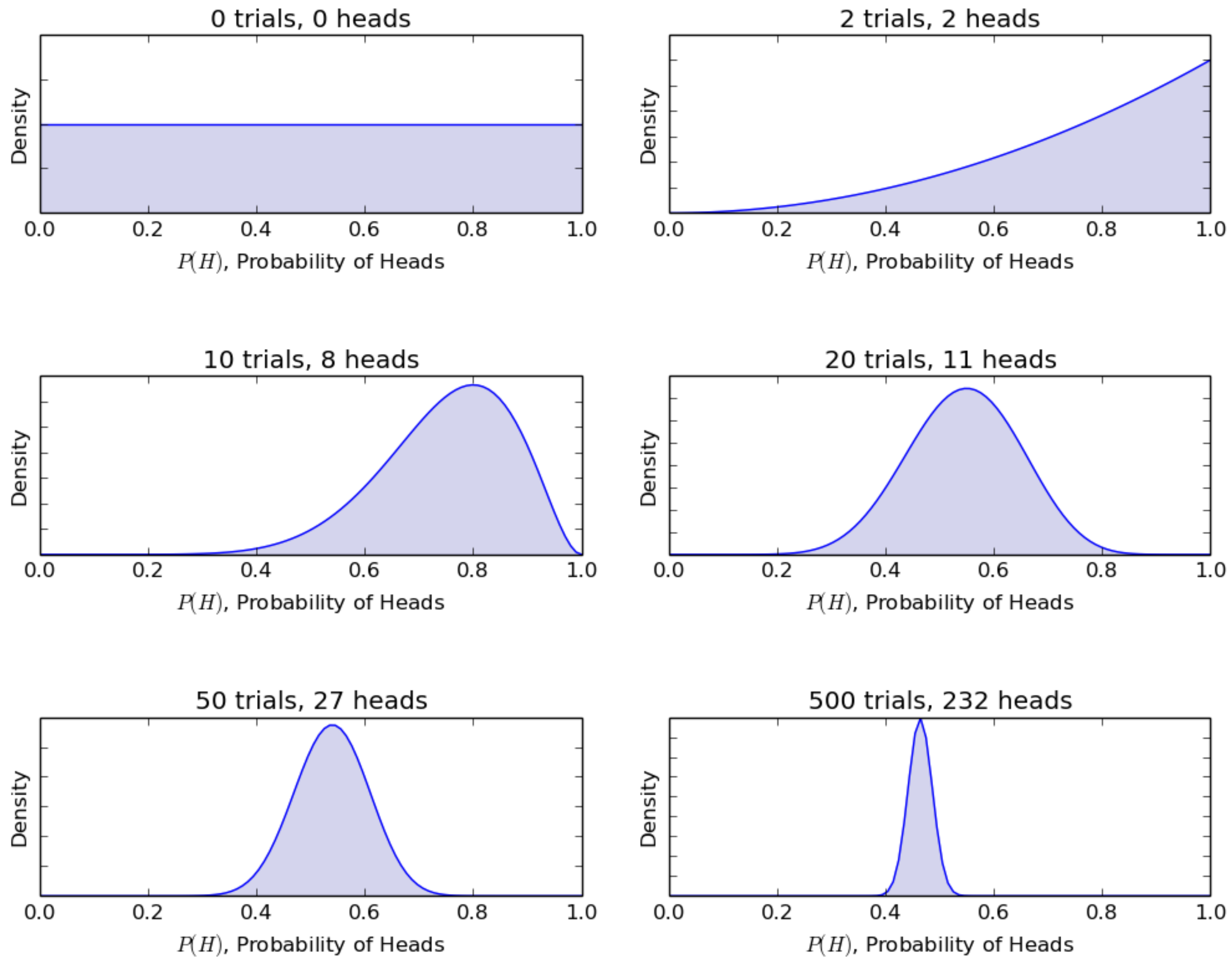
Appeal to past experience

1. We've never observed any such Goodman law to hold.
2. Standard, simple laws have a great track record

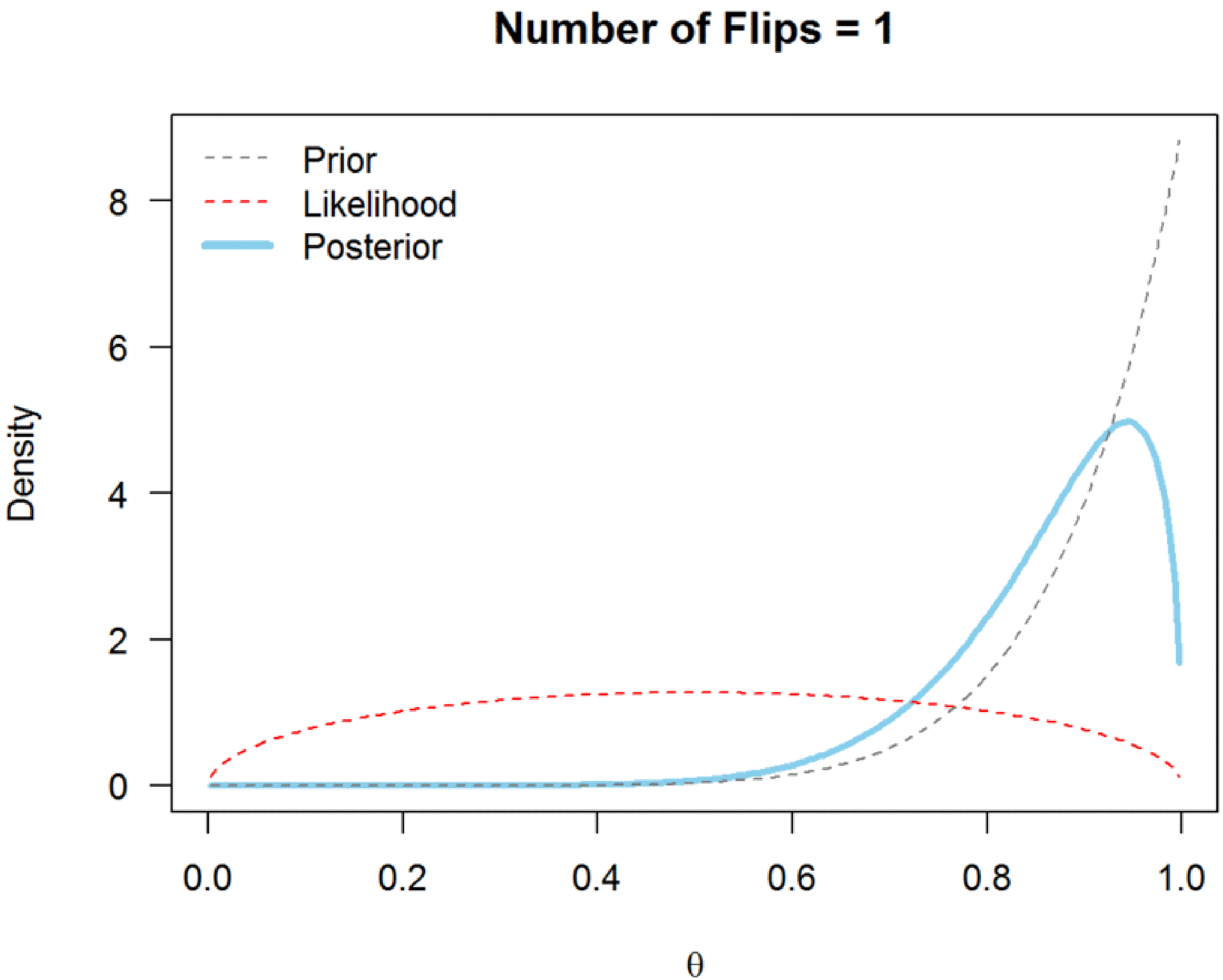
$\therefore$ Goodman laws are improbable

- The argument is circular, says Hume (and Skyrms, BonJour, etc.)

Washing out the priors



Fair coin, with head-bias prior



Washing out the priors

- This is an important feature of Bayesian reasoning.
- But does it render *a priori* knowledge obsolete, in actual scientific practice?
  - Or does it merely allow us to manage with **less** *a priori* knowledge, in favourable cases where the data are plentiful?
  - *Note*: if one's priors are extreme enough (i.e. close enough to 0 or 1) then the actual data will be insufficient to wash them out.